An Inside Look At Leather

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Hides and leathers need a closer look than ever, in the face of rising competition from substitute materials. If leather's present markets are to be preserved, research must be aimed at improvement of quality factors and physical properties. Since these factors are intimately related to microscopic structure, the microscope is becoming an increasingly valuable tool for showing how this structure is modified by defects or by changes in processing.

At the Eastern Utilization Research and Development Division laboratory near Philadelphia, we are using two special microscopes, each containing built-in photographic equipment for recording what we see, in our program of basic and applied research. One of these is a versatile light microscope capable of 1,000-fold magnification. It is also equipped for phase contrast and polarization—two variations of illumination which are extremely helpful in specific cases. The other is an electron microscope whose electron beam can extend the magnification to about 200,000 times. Collagen, the essential protein of hide, can thus be examined at the molecular level and at many intermediate degrees of aggregation.

Ordinarily, hide and leather samples for the light microscope are cut into thin sections, from 20 to 40 microns (0.0008 to 0.0016 of an inch) thick, on the freezing microtome. After staining for various components the sections are mounted on glass

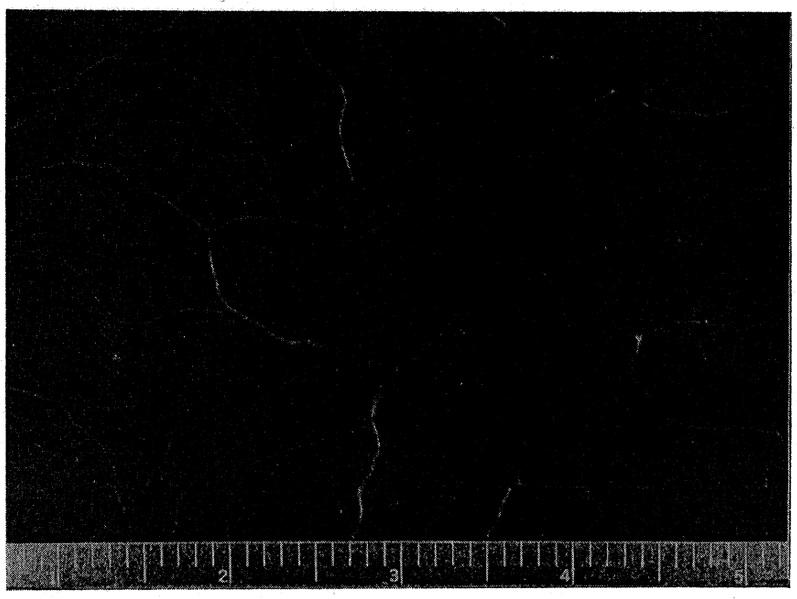

Fig. 1 Grain surface of veiny glazed calfskin leather (scale in tenths of an inch).

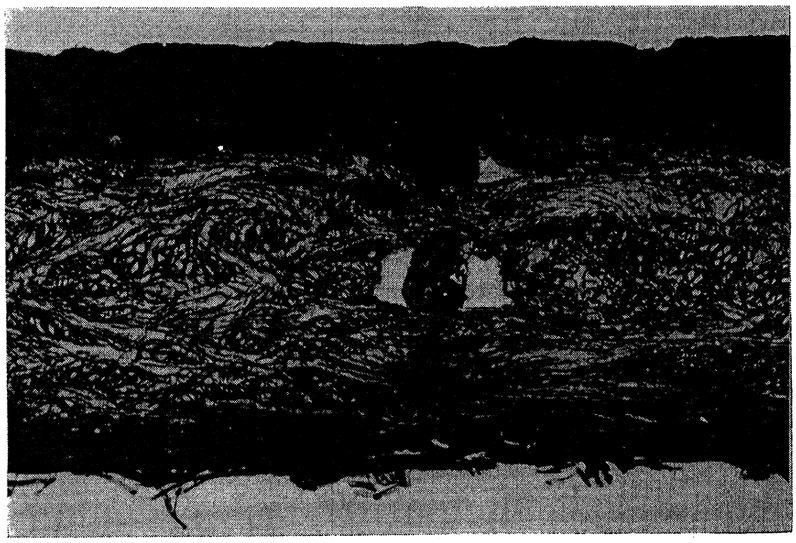

Fig. 2 Cross-section of veiny calf x 75.

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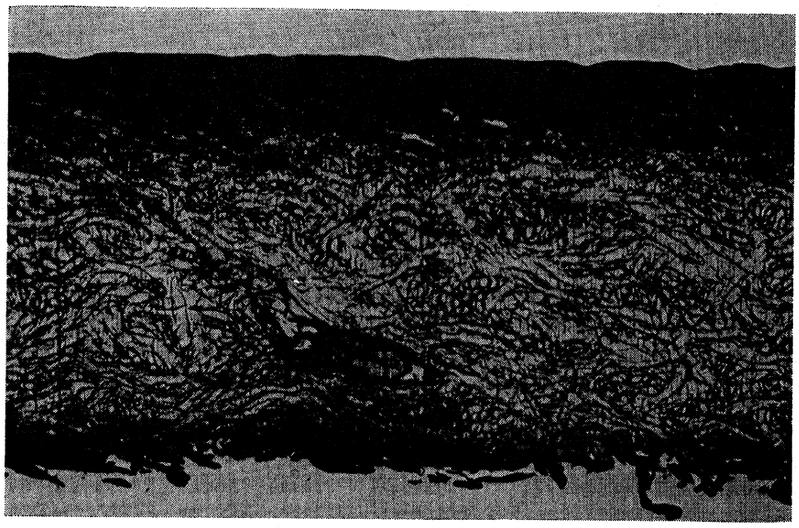

Fig. 3 Cross-section of non-veiny calf x 64.

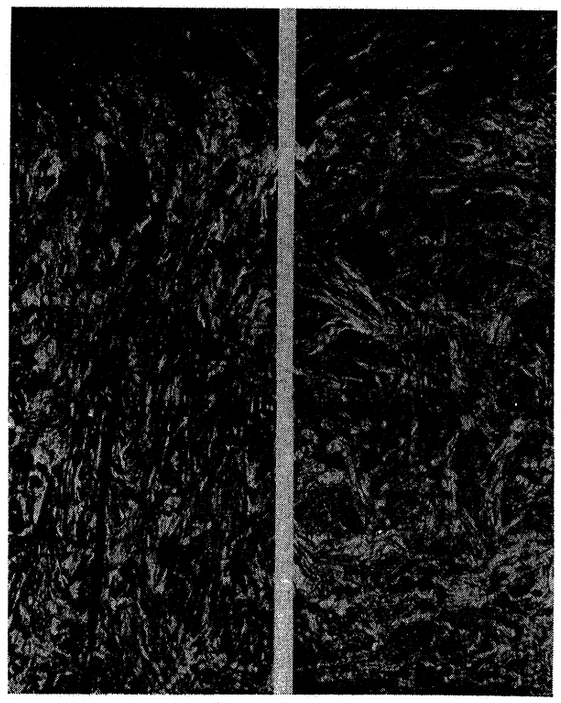

Fig. 4 Vertical cross-sections of cured hides: left, Hereford with vertical fibers; right, Angus with normal fibers x 17.

slides in the usual way. Or, if the material is especially fragile, it may first be embedded in gelatin and then hardened in formalin solution before sectioning. This is preferable to paraffin embedding since it does not disturb any of the natural or added fats. For the electron microscope special techniques are required to produce sections only a fraction of a micron thick. Small pieces of tissue are embedded in certain resins, cured to the desired hardness and cut with an ultramicrotome. In this case, thickness of the sections is indicated by the color of the light reflected from their surfaces, and the sections are mounted on wire grids instead of slides.

Currently the light microscope is being used to study several serious leather defects. One of these, particularly troublesome in glazed calfskin, is veininess or prominent blood vessel pattern (Fig. 1). Vertical cross-sections of veiny leather (Fig. 2) show large void spaces surrounding collapsed blood vessels directly beneath the surface blemishes. In non-veiny leather (Fig. 3) these spaces are much smaller or practically absent, indicating that veininess is not a surface phenomenon but rather a surface projection of faults in the subsurface structure. The actual cause of the voids is still unknown. Various proposals such as delayed cure, improper liming or bating, breed and seasonal differences, and many others have never been adequately explored. The search should be continued with more controlled studies. Corrective measures offer the most immediate promise: shaving to eliminate the deepest vessels; modified tannage giving better fullness of fibers; or directly filling the spaces with impregnating materials.

Another defect, encountered more recently, involves side leather made from certain plump Hereford hides almost exclusively. Microscopic examination revealed that the fibers in affected areas are arranged mostly perpendicular to the surface, instead of running nearly horizontal in an interwoven pattern (Fig. 4). For this reason it is called vertical fiber, and the split surfaces of such hides have a characteristic pulpy or mushy texture. As would be expected, vertical fiber leads to extremely weak leather that is worthless for shoe uppers. The immediate problem is to detect the condition before processing and to divert the hides to other uses. Contract studies at the Tanners' Council Laboratory are providing much useful data in this respect.

For experimental purposes, polarized light was found to be helpful for evaluating the extent of vertical fiber in cross-sections, especially in horizontal sections cut parallel to the surface. In such preparations (Fig. 5), vertical fibers appear dark while

horizontal fibers are bright. This permits rapid appraisal of the ratio of vertical to horizontal components in the complex fibrous architecture. It remains to be determined whether the defect is strictly of hereditary origin, as suggested by the data, or if it is produced by some environmental factors.

To provide a more comprehensive picture of fiber organization for basic studies, specially prepared sections are being examined in both types of microscope at overlapping magnifications. This helps in the interpretation of the resultant pictures, which is often the more difficult part of such work. At low magnification in the electron microscope (Fig. 6) the large collagen fibers look much the same as they do in the light microscope. At higher magnification (Fig. 7) it becomes apparent that each fiber in the fiber bundles is in turn composed of tiny fibrils (also grouped into bundles). At still higher magnification (Fig. 8) the fine details of fibril structure become evident, permitting specific identification of the protein and giving early indications of any degradative changes.

Such an approach is being used to investigate the basic differences in fiber structure in one half of a hide that was unhaired with lime-sulfide, compared with the other half unhaired with enzyme. It is known that hides so treated respond differently to the usual chrome tanning methods, but no difference has been detected in the fibrils. The hope is that significant organizational differences will become apparent as further samples are examined in both microscopes at intermediate levels of magnification.

Figure 8
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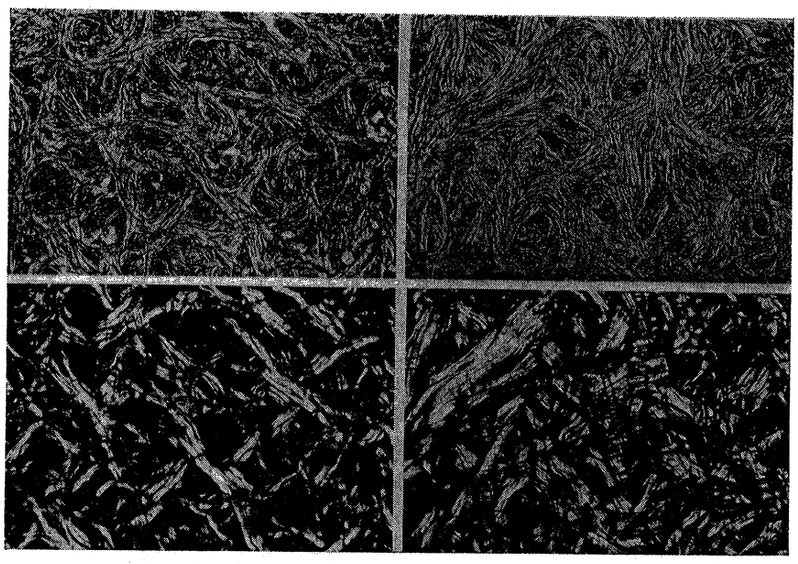

Fig. 5 Horizontal cross-sections through center of same hides shown in Fig. 4: left pair vertical fibers, right pair normal; upper views in regular light, lower in polarized light x 18.

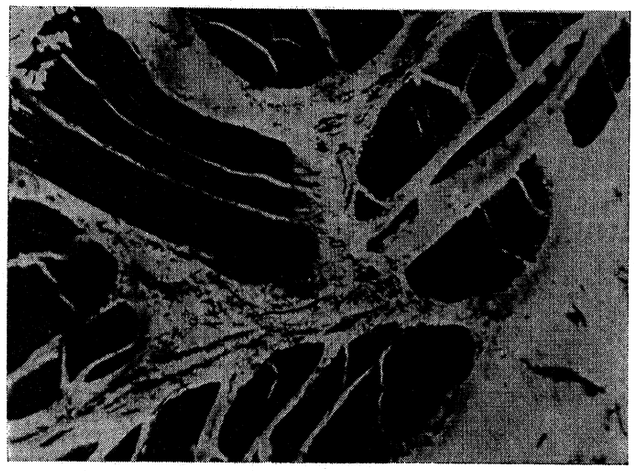

Fig. 6 Electron micrograph of hide section: longitudinal bundle in upper left, others in cross-section x 1,050.

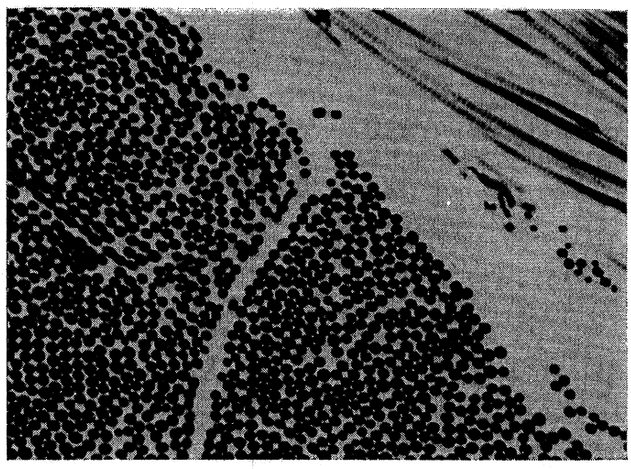

Fig. 7 Electron micrograph of hide section: longitudinal fibrils in upper right; two fibril bundles in cross-section x 17,230.

Fig. 8 **Electron micrograph of hide section: single fibril lengthwise, others in cross-section x 95,300.**